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Introduction

Computer networks now span the globe and can link users of electronic mail (e-mail) across great geographic distances. Networks link computer users via local, regional, national, and worldwide networks which provide access to other users and computer-based resources. Using a network, an instructor can tutor a student who is hundreds or even thousands of miles away. Tutor and student do not have to be at the same location or working in the same timeframe; a message dropped into an electronic mailbox will be read where received, when its recipient reads the e-mail.

Computer networks are a relatively recent phenomenon. They began in the early 1970s but have grown steadily so that presently they are accessible on most university campuses, in government laboratories, and at private firms involved in high technology and/or government contracting (Waggoner, 1992). Historically, network users have been fairly sophisticated technically, though improved software and the increased availability of commercial networks such as CompuServe have opened this resource to the general public.

Despite these improvements, much of the most widely-used e-mail software is demanding, unforgiving, and difficult to use. Interestingly, while networks are now widely available, they are not necessarily widely accepted or used to their full potential. Our informal observations in the Navy research and training communities suggested that some personnel made extensive use of available computer networks, while others assiduously avoided them. Anyone who has used e-mail on a regular basis has met or heard about users who seem unable (or unwilling) to master the basics of e-mail usage; regard e-mail as an intrusion on their privacy; feel that it blurs distinctions among levels on the organizational chart; enables glibness to be mistaken for insight; records for posterity words that are later regretted and wished forgotten, or who make other complaints.

Network acceptance and use have been studied formally by S.R. Hilitz, a researcher who began her work in the early 1970s with several studies of the Electronic Information Exchange System (EIES), alone and in collaboration with others (see Hiltz and Turoff, 1978; Turoff and Hiltz, 1978; Kerr and Hiltz, 1982). Hiltz, Kerr, and Johnson (1985) found that several factors predicted the success of introducing a network into a new user community:

1. Users must want the system at the outset.
2. There must be a "critical mass" of users interested in communicating with their peers.
3. Strong, active leadership (e.g., management support) must be present.
4. The system must have adequate features, a good user interface, and high reliability.
5. Users must be adequately trained.
6. Technical support must be readily available.

Perceived pressure to use the network was somewhat negatively correlated with network use. Surprisingly, typing ability did not predict network use.

To date, networks have seen limited use in education and training, although the use appears to be growing, and many colleges now permit students to take some courses via computer conference. Various studies have reported on their use in higher education. For example, Barnes, Swehosky, and Laguna-Castillo (1988) reported on a classroom experiment involving the use of a local area network to support a statistics course; students liked the new method of instruction, and performance was comparable to that with classroom instruction. In elementary education, Levin and colleagues experimented with the use of networks in the primary school classroom. In one study, students in classrooms in the U.S., Mexico, Japan, and Israel were linked by network and participated in group problem-solving tasks (Levin, 1985; Levin, Riel, Miyake, and Cohen, 1986). The authors reported that the instructional environment helped students gain insight into problems more fully than in a conventional classroom. In a related study, analysis of e-mail traffic in a networked instructional environment revealed that instructor-student discourse had more "strands" and persist-

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ed longer than that in the classroom (Quinn, Mehan, Levin, and Black, 1983).

The U.S. Army Research Institute recently tested the utility of e-mail to support reserve officer training. The project linked geographically separated students to an instructor and to each other for discussion in an electronic classroom and in smaller working groups. Students participated in computer conferences with their instructor and peers. The concept worked successfully but problems included student difficulties in setting up computer equipment, hardware breakdowns, lesson pacing problems, and misunderstanding of the rules of computer conferencing (Richards and Phelps, 1987; Phelps and Richards, 1987; Richards, 1988). The problems the Army experienced demonstrate that e-mail systems can be difficult to operate, support, and use successfully in training.

Early in our work we concluded that for e-mail systems to succeed in the world of education and training, they had to be designed so that they could be mastered without extensive training and could be used with minimal practice and technical support. Our research and development work was an attempt to build such a system and to test it as an aid in correspondence instruction. The system we developed and evaluated is called the Instructional Support Network (ISN). The ISN was envisioned as a user-friendly e-mail system that could be used for communication, tutoring, and conferencing with minimal training and technical support. The ISN eventually developed allowed students taking correspondence courses to communicate via e-mail with an expert tutor to discuss course subject matter, answer student questions, provide student feedback, and handle course administrative matters.

We tested the ISN concept in the continuing education program at the U.S. Naval Postgraduate School (NPS), in Monterey, California. The NPS is a graduate-level institution that enables active-duty military personnel to obtain advanced degrees in the naval sciences and engineering. At the time of our research, the NPS continuing education program enabled non-resident students to take selected courses by correspondence. The majority of these students were stationed hundreds of miles from the NPS. The correspondence courses offered were versions of those taught at the NPS and were technical and difficult (e.g., college-level mathematics and physics). Correspondence students were supposed to recruit a local tutor knowledgeable in the particular subject area to help them with their studies, but often they were unable to find one. The attrition rate in these courses was much higher than for correspondence courses generally. Probable reasons were course difficulty and lack of adequate tutoring. The ISN had the potential to overcome the tutoring limitation by linking students to an expert tutor at the NPS, and it was for this reason that we selected the NPS program as our research testbed.

ISN Design and Development

Our notion was to provide continuing education students with the hardware, software, and procedures needed to enable them to communicate with their calculus tutor at the NPS via e-mail. ISN hardware and software would be packed in boxes and shipped to students at remote locations, where they would be required to put everything together and make it work. There was no reason to expect students to have computer skills, and it would not be feasible to train students face to face. Thus, it became apparent that the ISN had to satisfy certain basic design requirements:

1. ISN hardware had to be economical, rugged, and easy to assemble.
2. User documentation had to be simple and "foolproof."
3. Users would have to be able to assemble and operate their systems and diagnose simple problems using only the documentation provided.
4. Users without computer skills would have to be able to use the ISN successfully.

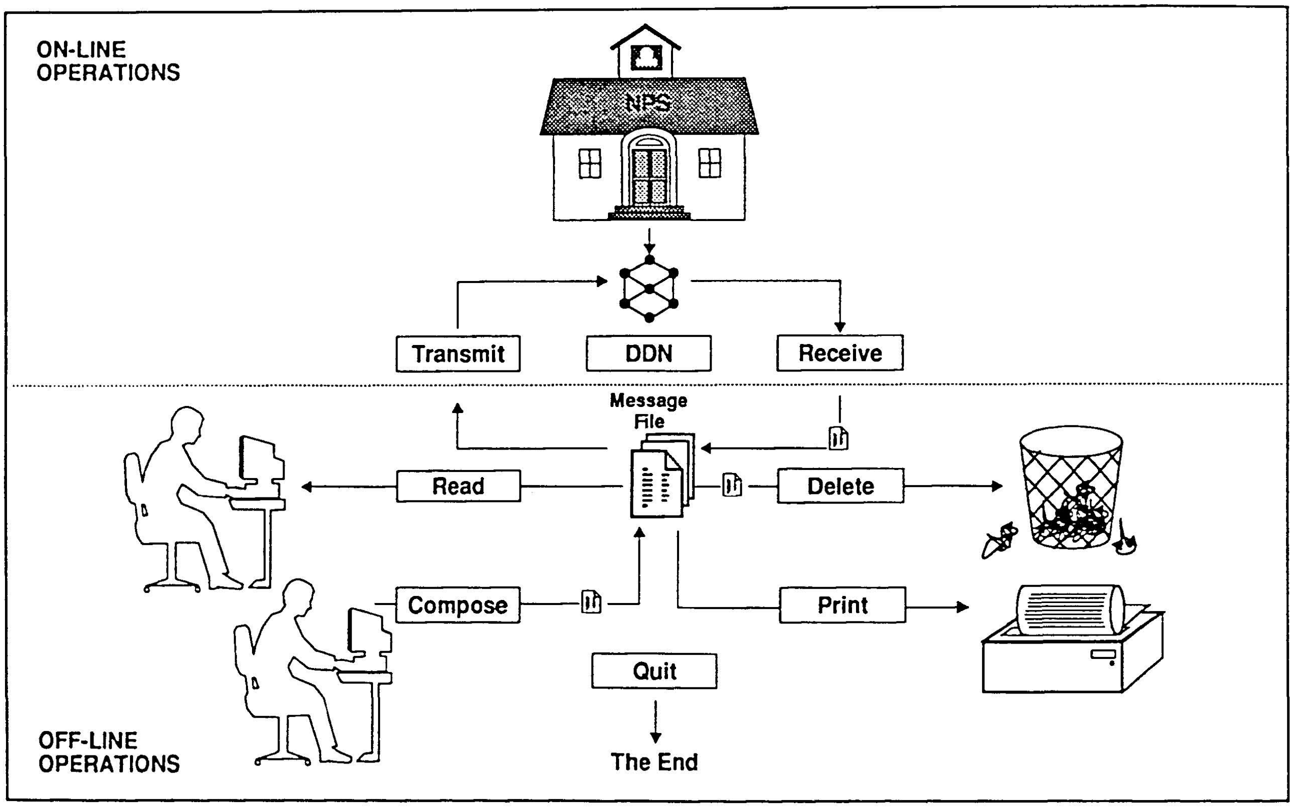
We selected hardware based on low cost, compactness, ruggedness, and ease of assembly (one cable connection). The ultimate choice consisted of IBM PC XT-compatible Zenith-184 laptop computers and compact ALPS printers.

We evaluated several off-the-shelf terminal programs and rejected all because they would take too long for users to learn and/or would be too difficult to use. (During our initial search we were advised by one educational institution that all new students were required to use a particular commercial program and assured that it was "simple and straightforward." Two days of unsuccessful attempts to communicate using this program and frustration with its prolix documentation led us to conclude that the institution was perpetrating a form of cruel and unusual punishment on its hapless student body.) Eventually, we hired a software contractor to develop a turnkey program that adhered to four design principles based on recommendations commonly made in computer user-interface design guides (e.g., Engel & Granda, 1975; Smith and Aucella, 1983):

1. **Simplicity**: The program has the minimum number of functions necessary to perform its job, and only one way to perform each action.
2. **Visibility**: Menus display and explain all possible program and help options.

Figure 1

Organization of Instructional Support Network Program



3. **Consistency**: Screens are laid out according to a common template, and information is displayed and options are exercised similarly from screen to screen.
4. **Unbreakability**: No matter *what* the user does, the program must *not* "crash."

The ISN program was developed, tested, debugged, and refined over a period of several months and ultimately reached the stage where we were satisfied that it achieved all four design principles. The program combines a text editor, terminal program, and simple e-mail program. Students use the software to compose and transmit messages to their tutor over the Defense Data Network (DDN), and to receive and store messages the tutor sends to them. The software is set up before being provided to the student with the user's encoded password, user ID, account information, phone number to dial, and other information required for communication over the DDN. The user is required to turn on the computer and to type in a password to assure that he or she is authorized to use the ISN but does not have to dial a phone number, turn on a modem, copy files, use hierarchical directories, or deal with other computer *arcana.* In short, the software was made as simple and foolproof as possible.

Program organization is illustrated in Figure 1. The seven program options are Transmit, Receive, Read, Compose, Delete, Print, and Quit. The function of each of these operations is described in the program's main menu screen (see Figure 2).

The ISN communicates via the DDN to an IBM mainframe host computer. A dilemma we faced was that we could control ISN software fully, but were vulnerable to problems caused by the DDN and the host computer. It was our hope during development that problems with the DDN and host would not compromise effectiveness. In this connection, we eventually learned some important lessons which are discussed below.

Figure 2

Instructional Support Network Main Menu Screen
for Student Software

Instructional Support Network (ISN)

Main Menu

>> RECEIVE: Receive mail messages from your tutor at NPS.

READ: Read mail messages received from your tutor at NPS.

COMPOSE: Compose mail messages to your tutor at NPS.

TRANSMIT: Send mail messages to your tutor at NPS.

DELETE: Select and delete mail messages.

PRINT: Select and print mail messages.

QUIT: Leave ISN program and return to DOS.

Use ↑ and ↓ to select menu option. Then press the ENTER key.

We wrote a concise, illustrated, cookbook-style ISN user's guide covering system assembly and testing; a tutorial on how to use the ISN program, communication conventions, and how to handle problems (Navy Personnel Research and Development Center, 1989). Figure 3 shows a typical page from the guide. It was hoped that users would read the guide, but the assumption had to be made that they might not. Consequently, users were provided with a hot-line phone number to call in the event of problems, and the software was written to be internally self-documenting.

ISN Evaluation

We conducted a six-month field test during which a mathematics tutor at the NPS used the ISN to tutor students taking calculus correspondence courses. Before beginning the field test, we arranged to have all student and tutor messages sent both to the addressee and to a file accessible to us so that we would have a historical record of all student-tutor communications. We held a series of meetings with the tutor before, during, and after the field test, kept notes of comments, and eventually compiled them. The software contractor maintained records of all problems encountered during software development and field testing and eventually documented them in a report (Newbury, 1989).

We initially assessed ISN ease of learning and operation by conducting a formative evaluation before the field test. We solicited five test subjects who had little or no computer experience and showed each subject to a room with a copy of the ISN user's guide to unpack and set up the ISN and to use it to

Figure 3

Typical Page from Instructional Support Network User's Guide

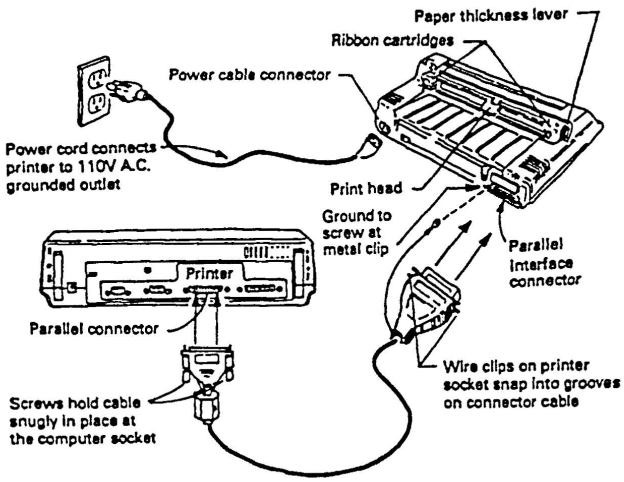


Figure 1-8. Connecting the printer cable.

7. Locate the grounding clip on the printer end of the cable.
8. Connect the grounding clip to the Phillips head screw above and to the left of the cable connector on the back of the printer (see Figure 1-8).
9. Connect the power cord to the back of the printer.
10. Plug the power cord into a grounded outlet.
11. If a floppy disk is in the drive of your Z-184, remove the disk.
12. Turn on your Z-184.
13. Turn on your printer.

send and receive a message. The researcher then left the room and waited for the subject to complete the guide to unpack and set up the ISN and use it to send and receive a message. Subjects worked alone in the room, without outside help. All subjects were able to complete the assigned task successfully in less than two hours. During post-task interviews, all subjects stated that they had found the user's guide easy to understand and the software itself easy to use. They offered suggestions for improving the ISN software and user's guide that we later followed. During the subsequent field test, all students were able to assemble their ISN equipment and in short order communicate via e-mail without significant complications. In most cases, students did this without making hot-line calls.

The ISN required several kinds of support. Support personnel included a full-time tutor and a part-time software engineer who monitored the network to identify, diagnose, and correct technical problems and provide technical support. In addition, a researcher was available to provide hot-line support to students who were experiencing difficulties, and personnel in the NPS computing center provided occasional support to ISN users. The amount of support was greater when the system was being set up than after it had reached a steady state and was running smoothly. After that point was reached, the technical support by the software engineer averaged one or two hours per week, hot-line support about 30 minutes per week, and computer center support about 30 minutes per week. The tutor estimated that he could have tutored as many as 40 students with the ISN (and perhaps more), since he was able to tutor 10 students in less than 10 hours per week.

The ISN works within a complex arrangement of computers, software, and long-distance networks. System operability depends on all components working properly, and the failure of any single component usually compromises the entire system. While the ISN was in use, nearly every part of the system failed at least once. Most failures were minor and were quickly corrected, but a few affected the ISN for several weeks and required software modifications. All ISN problems were reported via hot-line calls and were corrected quickly, usually by sending the student replacement hardware or a diskette containing appropriate software. Non-ISN problems were also usually reported via hot-line calls but could not be corrected as quickly because they required actions by personnel at the host computer, DDN, or telephone company. Most ISN failures were caused by factors other than ISN hardware and software, and these failures were the most time-consuming to correct because they were outside our immediate span of control.

Ten students who had used the ISN were interviewed by telephone after the course and asked to rate various dimensions of the class they had taken and the tutor they had worked with. (Class dimensions rated were usefulness, quality, and difficulty; tutor dimensions were responsiveness, mathematics knowledge, and tutoring skill.) A comparison group of 20 students participating in traditional training was contacted and asked the same questions. Because of the small number of students participating in these followups, we do not report statistical results here. However, on all dimensions, students in the ISN group gave slightly more favorable ratings than those in the traditional group and in all cases these ratings were above the midpoint on the rating scales used. Though the differences between groups on most of these ratings are quite small, they suggested that students in the ISN group were more favorably disposed toward their learning experience than those participating in traditional instruction.

The NPS tutor was interviewed at the conclusion of the field test concerning his perceptions of ISN strengths and weaknesses. In addition, he provided written comments. What follows is a composite of the tutor's spoken and written comments. As an overall assessment of the ISN, the tutor stated that it was a "great" tutoring tool that was easy to learn and use by both students and tutor in a short time. The tutor identified several ISN-related problems during the field test:

1. **Lack of communication by students:** Students were required by the terms under which they were lent their computer to communicate at least once per week. Most did not communicate this often, or communicated in a very cursory fashion.
2. **NPS host computer problems that precluded student-tutor communication:** The host computer at various times rejected or lost ISN messages and it was not evident to communicators that their messages were not getting through. This problem was caused by unanticipated side effects of IBM software modifications and was only detected after long periods of non-communication.
3. **DDN problems that precluded student-tutor communication:** The DDN, at various times, disrupted communication. The primary cause was unreliable phone lines that would reject communications.
4. **Inability (by tutor) to diagnose cause of student non-communication:** There was no easy way to tell whether lack of communication was caused by student disinterest, ISN computer or software, host computer problems, or DDN problems.

Discussion

The evaluation proved the ISN to be what we had hoped it would be. It was economical, rugged, and easy to assemble. Users with limited computer skills could learn to operate it based on written and within-program documentation, with little or no outside technical support. A system such as the ISN makes the powerful tool of e-mail available to people who lack computer sophistication or who choose not to master more complex messaging systems. Supporting a system such as the ISN requires specialized technical skills, but the actual amount of time required by each specialist is relatively low. □

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